Abstract for Spacecraft Thermal Control Technology Workshop on
March 1-3, 2000 at Aerospace Corporation, Los Angeles

Novel Lightweight Thermal Insulation Types for the Martian Environment: Using Carbon Dioxide Gas and Aerogel in Lightweight Enclosures

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Abstract

Two new types of lightweight thermal insulation for the Martian environment are being developed and evaluated. In one, the ambient (10 torr) carbon dioxide of Mars is used as the insulating medium with a multilayer insulation enclosure separated by Mylar stand-offs. This thermal insulation is lighter, cheaper, and much faster to fabricate and install on Mars landers and rovers and their payloads than the insulation used in the past Mars missions. The thermal insulation used on the past Mars landers and rovers have been based on fiberglass batt material, aerogel, and Eccofoam. While the performance level of the new insulation is similar to the traditional insulation, the new insulation is 60% lighter, 75% cheaper, and 60% faster to fabricate and install on the payload. After a thorough analytical and experimental evaluation, it has been chosen to be used on the Payload Electronics Box, Pancam, and mini-TES instrument of Mars '01 lander.

One of the advantages of using carbon dioxide is that the thermal conductivity of the gas is very close to aerogel and batt material. Aerogel insulation requires an enclosure to provide structural support; no such structural support is needed for the carbon dioxide. A much larger mass of fiberglass batt material is needed to achieve a thermal performance equivalent to carbon dioxide. Additionally, the convective heat transfer between the inner and outer walls of the insulation containing the gas is small wall gaps up to 8 cm. The total thickness of the new insulation used for the Mars '01 lander is less than 5 cm.

The second type of lightweight insulation is based on aerogel material injected into a very lightweight glass fiber structure. This provides a rigid insulation that can be installed on the outside of the landers, rovers and their payload. The lightweight glass fiber structure can be molded into any shape needed and the aerogel is injected into the molded shape. Unlike the gas gap insulation, this insulation provides a rigid structure to support installation of equipment on the outside of the insulation. For a comparable thermal performance, a significant mass savings can be realized compared to the insulation material used in the past. Test coupons are currently being fabricated and will be experimentally evaluated during the final months of 1999.

This presentation at the 2000 Aerospace workshop will include the experimental results from the evaluation of these two lightweight thermal insulation for the Martian environment. The lessons learned in the design and application of this insulation for Mars '01 lander payload will also be presented.